MANN MATERIALS PTY LTD

Test Data

Mann Senior Safety Anti-Fall Flooring

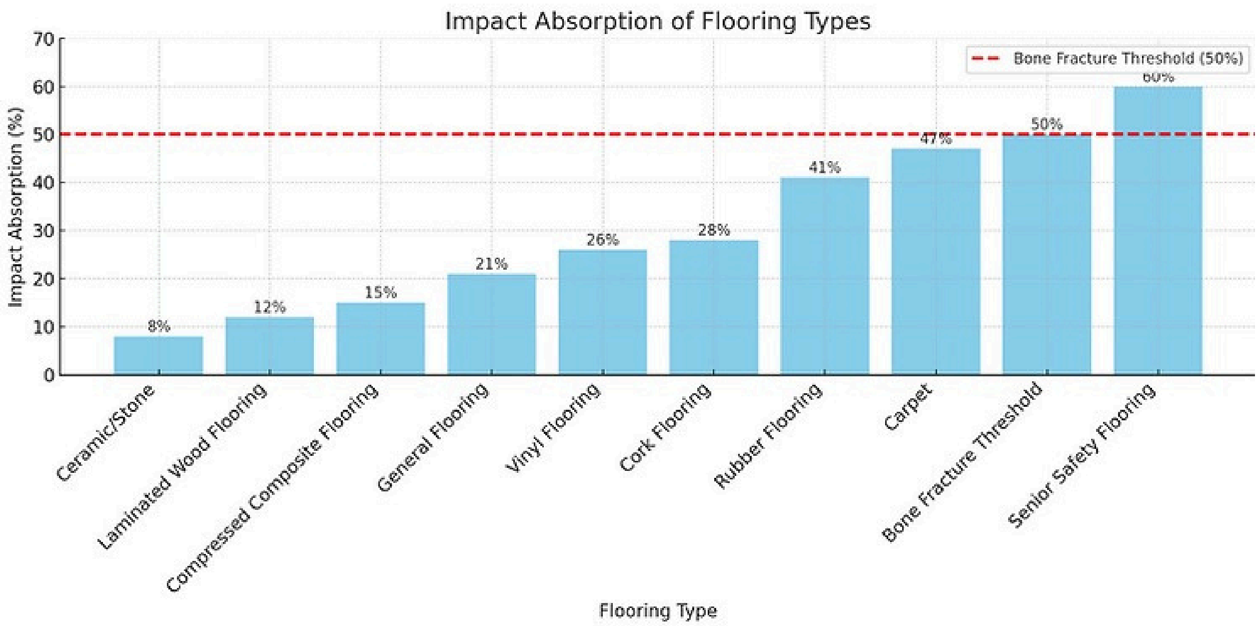
Modern Flooring Is Inadequate for Fall Injury Protection

Modern flooring is usually hard and unforgiving during a fall for the elderly. As people age, bone density goes down. This means a fall on common types of flooring such as ceramic/stone, laminated wood flooring, hardwood flooring, vinyl flooring, cork flooring, rubber flooring or even carpet can lead to serious injuries.

By installing our Mann Anti-Fall Flooring, one can reduce fall severity by absorbing a percentage of the impact, making it the safest choice for elderly homes. Our flooring is designed specifically to reduce fall injuries in high-risk areas in your home like the kitchen, bedroom and living room.

Why take chances with standard flooring when you can invest in a product that offers unparalleled protection? Our Anti-Fall Flooring not only provides cushion from falls but also enhances comfort and mobility, ensuring that every step is a safe one.

Choose Mann Anti-Fall Flooring — because safety should never be compromised.



Source: Resultsfromimpactabsorptiontestsdoneper EN 14808 standards at at (23 ± 2) °C

Our Technology

Our cushioning meta-material technology allows anyone to walk on our flooring just like a normal surface - it will not collapse or buckle. Upon impact, the floor is designed to buckle under pressure which soaks up the impact of falls. The impact absorption rate is up to 60%+.

Inadequate Impact Absorption Of Popular Flooring

Plastic/Linoleum/Rubber Without Shock Absorbing Backing

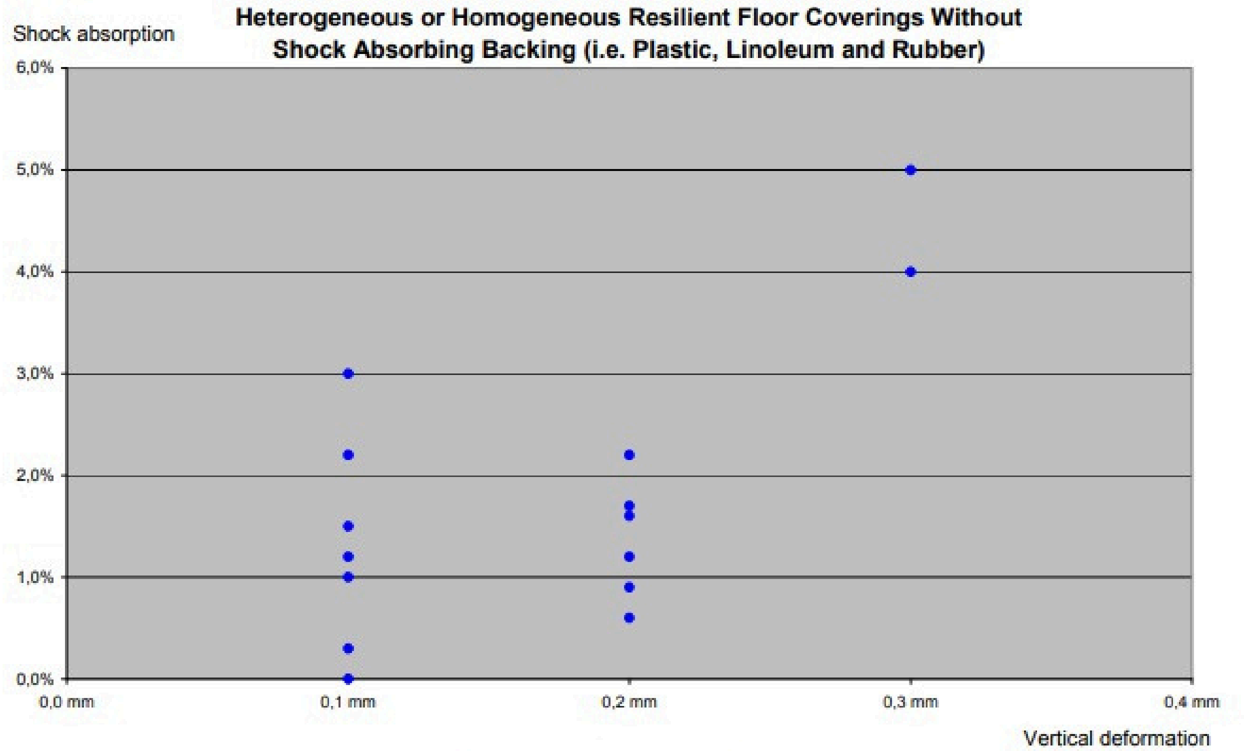
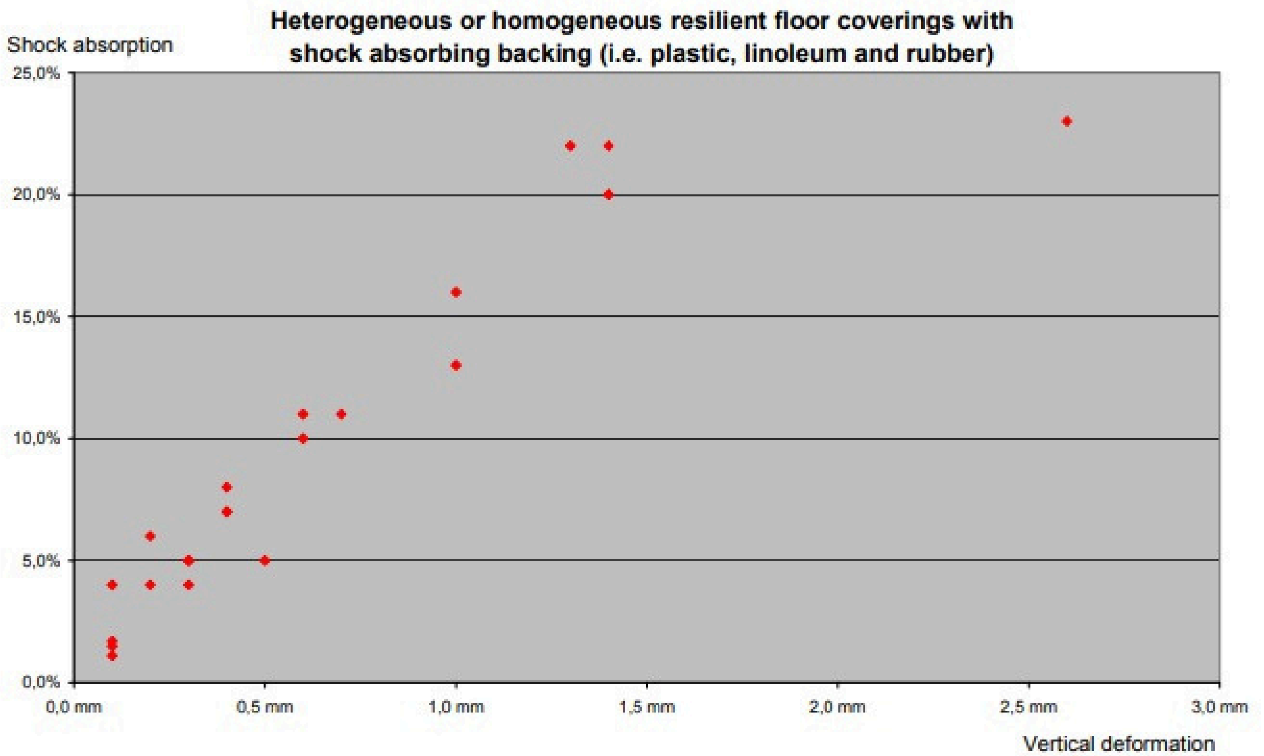


Chart 1 Results, Shock absorption plotted against vertical deformation

Source: SP Technical Research Institute Of Sweden – Determination Of Mechanical Comfort Properties Of Floor Coverings (Ingvar Demker)

Result: 0%–5% Impact Absorption

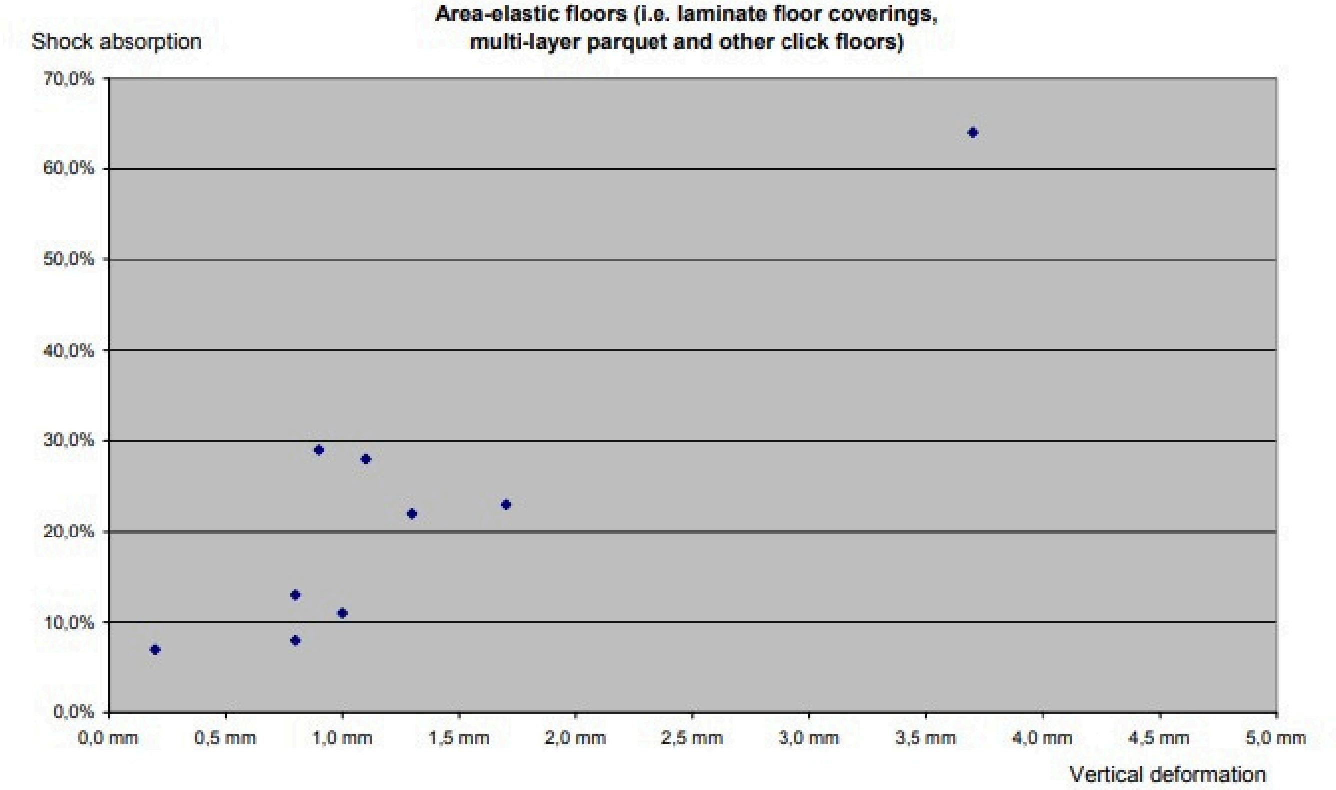
Plastic/Linoleum/Rubber With Shock Absorbing Backing



Source: SP Technical Research Institute Of Sweden – Determination Of Mechanical Comfort Properties Of Floor Coverings (Ingvar Demker)

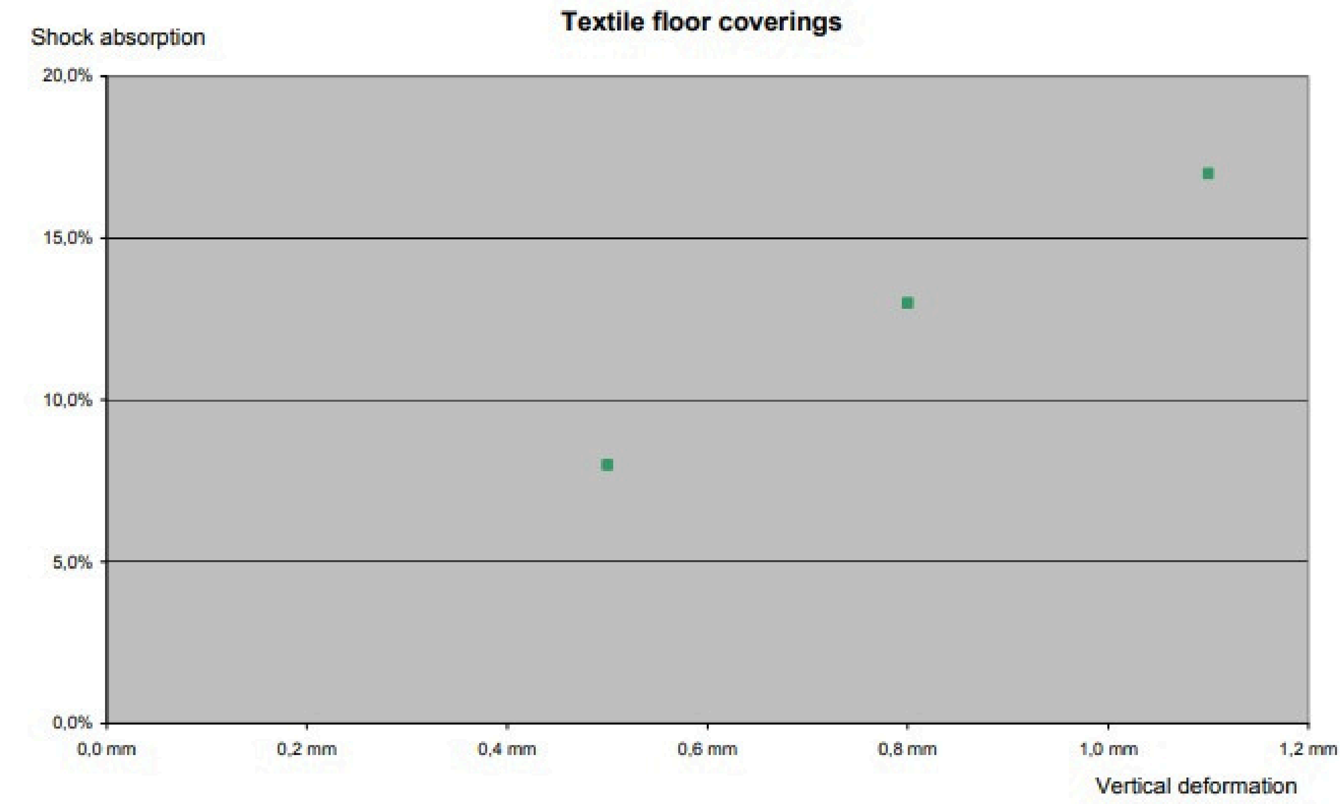
Result: 0.5%–23% Impact Absorption

Laminate, Multi-layer Parquet and other Click Floors



Source: SP Technical Research Institute Of Sweden – Determination Of Mechanical Comfort Properties Of Floor Coverings (Ingvar Demker)

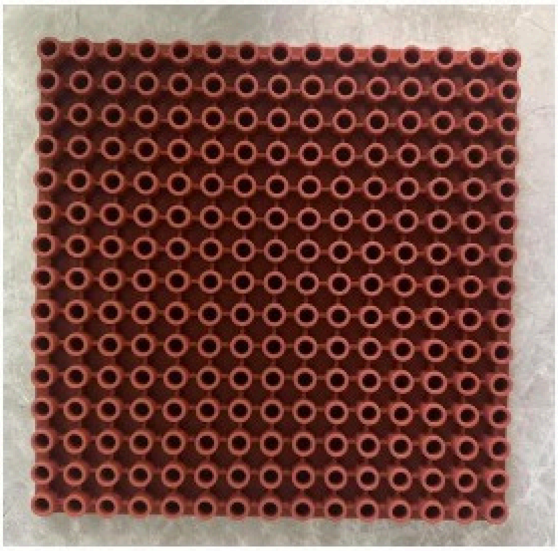
Result: 8%–29% Impact Absorption

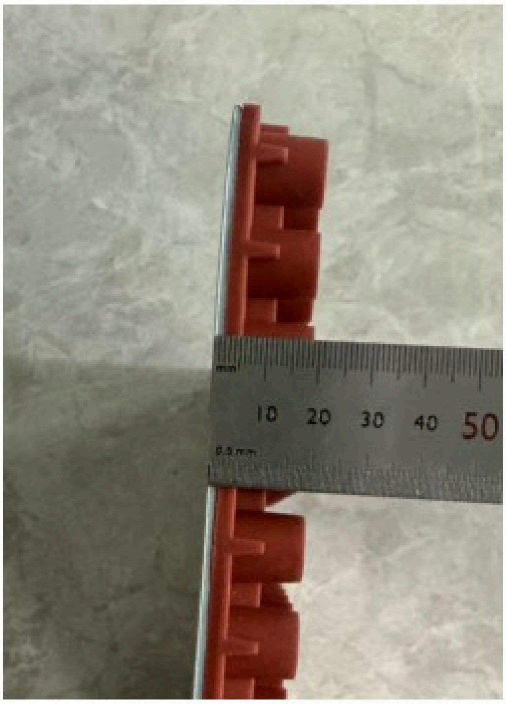


Source: SP Technical Research Institute Of Sweden – Determination Of Mechanical Comfort Properties OfFloor Coverings(IngvarDemker)

Result: 8%–17% Impact Absorption

Impact Absorption Test – Silicone Base



Scope:

Determine the percentage reduction in peak impact force of a surface relative to a rigid reference (concrete). Result is reported as Shock absorption / Force reduction, %.
Apparatus (Berlin Artificial Athlete)

- Falling mass: 20.0 kg, with a defined protrusion on the impacting base.
- Spring: nominal stiffness ~2 $MN \cdot m^{-1}$ with radiused top cap.
- Force transducer: capacity ≈10 kN with 0.1% system accuracy.
- Test foot: Ø 70 mm, spherical radius 500 mm.
- Drop height: 55 mm.
- Rigid reference base: high-quality concrete anvil (with inset steel plate) for the reference impacts.

Environmental conditioning

Condition specimens and conduct testing at (23 ± 2) °C

Calibration / reference check

Verify the device and data acquisition by taking readings on the concrete reference.

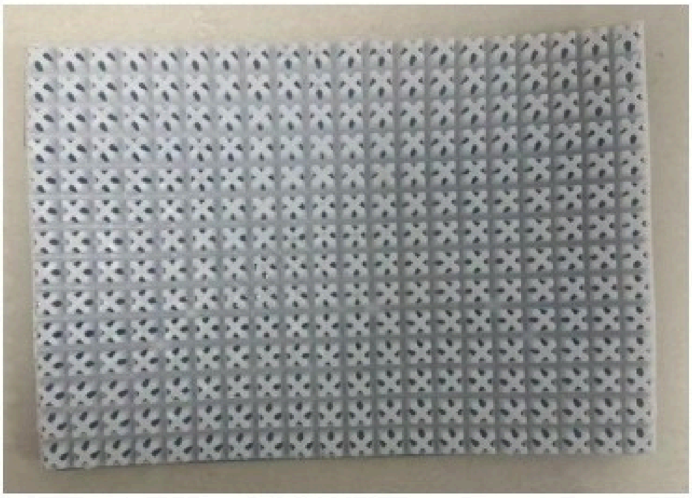
Test procedure

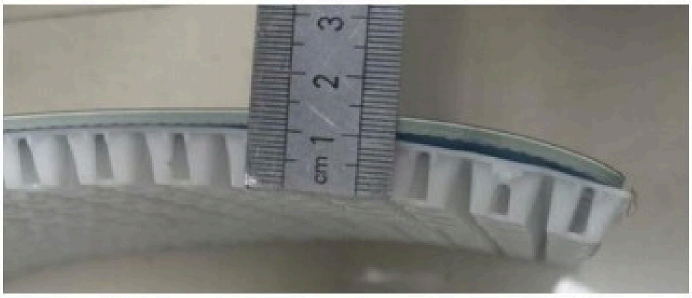
1. Reference impacts on concrete: Mount the apparatus over the concrete anvil and release the 20 kg mass from 55 mm; record the peak impact force (F_c).
2. Impacts on the test surface: Place the apparatus on the floor specimen; perform impacts from the same height and record peak force (F_s) at the specified test locations
3. Signal acquisition & filtering: Capture the force–time signal from the transducer. Apply anti-alias filtering; a 9-pole Butterworth ~220 Hz low-pass is widely recommended for Berlin-Athlete traces to ensure consistent peak determination.
4. Computation: Calculate shock absorption as the percentage force reduction versus concrete: R=Fc−FsFc×100%R = \frac{F_c - F_s}{F_c}\times 100\%R=Fc Fc −Fs ×100% where F_c is the peak force on concrete and F_s on the specimen. Report to 0.1%.

Results:

Shock absorption (force reduction) 60.2% at 23 °C, tested per GB/T 14833 (Berlin Artificial Athlete, equivalent to EN 14808); aligns with ASTM F2772 Class C5.

Impact Absorption Test– Polymer Base





Results:

Shock absorption (force reduction) 55.1% at 23 °C, tested per GB/T 14833 (Berlin Artificial Athlete, equivalent to EN 14808); aligns with ASTM F2772 Class C5.

Video Demonstration

Wine Glass Test - The wineglass is used to comparethe fragility of a senior's bones. If you drop a wine glass on hardwood, tile or even carpet, the wine glass would normally break or shatter but bounces off our flooring:

https://youtube.com/shorts/KiwvKjfeANQ?feature=share

Glass Cup Test - The same is demonstrated with a glass up

https://youtube.com/shorts/BJNae3Fv8X0?feature=share

Buckle Test - When you stand on it normally, it does not buckle. When you fall, the floor buckles and softens your fall

https://youtube.com/shorts/xkYW9V-gwMg?feature=share

Wine/Bowl Drop Demo

https://youtube.com/shorts/XMywoVV5qm4?feature=share

Knee Drop Test - Falling down on knees on hardwood, tile or even carpet would certainly lead to bruising, injury or even fractures. However it is soft upon impact on our floor:

https://youtube.com/shorts/8xBvU8IhNY8?feature=share

Original Research For Metamaterial Flooring Technolgy

OPEN ACCESS

Shock- absorbing effect of flooring- adopted mechanical metamaterial technology and its influence on the gait and balance of older adults

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[redacted]

ABSTRACT

Objective To elucidate the performance of a shock-absorbing floor material with a mechanical metamaterial (MM- flooring) structure and its effect on the gait and balance of older adults.

Methods The drop-weight impact was applied to evaluate the shock-absorbing performance. The falling weight was adjusted equivalent to the energy exerted on the femur of an older woman when she falls, which was evaluated on the MM- flooring and six other flooring materials.

Nineteen healthy people over the age of 65 years participated in the gait and balance evaluations. The timed up and go and two- step tests were adopted as gait performance tests, and the sway- during- quiet-balance test with force plates and the functional reach test (FRT) were adopted as balance tests. All the participants underwent these tests on the MM- flooring, shock- absorbing mat and rigid flooring.

Results The shock- absorbing performance test revealed that MM- flooring has sufficient shock- absorbing performance, and suggesting that it may reduce the probability of fractures in the older people when they fall. The results of the gait performance test showed that the participants demonstrated the same gait performance on the MM- flooring and the rigid floor. In the quiet standing test, MM- flooring did not affect the balance function of the participants to the same extent as the rigid floor, compared with the shock- absorbing mat. In the FRT, no significant differences were found for any of the flooring conditions.

Conclusions MM- flooring has the potential to prevent fractures attributed to falls and does not affect the gait or balance of older adults.

INTRODUCTION

Falls are associated with health risks, such as deterioration of physical functions and limitation of activities of daily living. Considering the incidence of proximal femoral fractures, epidemiological studies have demonstrated that more than 85% of proximal femoral fractures are attributed to falls; the number of falls is a risk factor that increases gradually from 40 years, with a steep increase after 75 years of age.1 Clinical vertebral and hip fractures are associated with a substantial increase in the mortality of relatively healthy older women.2 Although falls are a risk that should be avoided, their complete prevention is impossible in humans who walk on two legs. At least one-third of community-dwelling people aged over 65 years report incidences of fall each year.3

To prevent serious injuries, such as fractures in the event of a fall, research is being conducted on flooring materials that specialise in shock absorption.4 Their aim is to reduce the risk of fractures by cushioning the flooring to mitigate the concentration of the impact force of falls.5 Although softer floors would provide greater attenuation in the fall impact forces, excessive reduction in the floor stiffness may increase instability/body sway, impair mobility and balance, and increase the risk of falls.6–8 Thus, there is a need to consider the effect of the softness of the floor on the body balance. A flooring material with adequate shock- absorbing effect that does not affect gait and maintain balance would be useful in preventing fall-related injuries.

Shock-absorbing flooring materials using conventional materials and using the structural knowledge of mechanical metamaterials (MM- flooring) have now been developed (figure 1). MM are materials for which the macroscale properties are deter- mined by a small-scale topological design.9 These are a class of artificial materials with rare anoma- lous mechanical properties,10 which have attracted scholarly attention owing to their superior properties.9 11 An example of the use of this technology is the production of auxetic materials,12 which decreases in thickness perpendicular to stress; this property is not observed in nature. This technology can render a rigid object flexible by modifying the structure to distribute the force such that it deforms in a different or torsional direction in response to the force applied to the object.10 13 Furthermore, with the advent of three-dimensional printing, creating objects with complex internal structures has become possible,12 which is expected to be used in various fields to produce materials with more detailed structures and improve production efficiency.11 The newly developed MM- flooring is made of thermoplastic elastomer and has a MM structure that maintains its hardness under normal loading and walking and distributes the impact in the contact area in the event of a fall, thereby providing high cushioning and shock absorption. Confirming the shock- absorbing and walking stability of this flooring material would help resolve the traditional trade-off problem from a structural

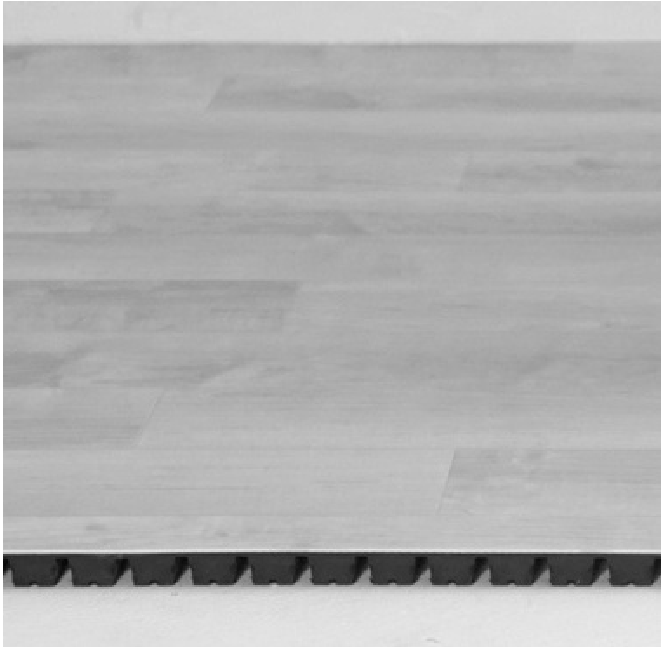

Figure 1 The MM-flooring. Newly developed flooring material with a mechanical metamaterial structure (MM- flooring). MM- flooring, mechanical metamaterial flooring.

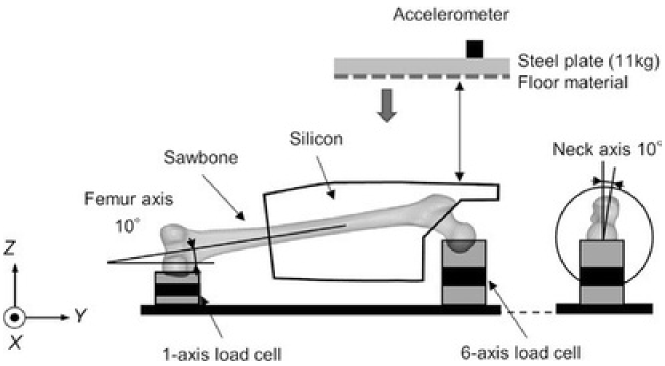

Figure 2 A schematic diagram of the drop weight impact test. Steel plates were set at 230 mm to render the energy equivalent to that of a person with a height of 149.3 cm and weight of 55.3 kg. Each flooring material was attached to the base of a steel plate that was dropped and impacted on the femur model. A silicon rubber shock- absorbing material was attached around the greater trochanter of the femur model as the soft tissue of the buttocks. The force sensors were placed at the femoral head to detect the impact acting on the femur when the weight collided.

point of view. This study aimed to compare the shock- absorbing performance of MM-flooring with that of other shock- absorbing flooring materials and examine its effects on walking and balance in healthy older adults.

METHODS

Experiment 1: effect of shock-absorbing

Floor conditions

The MM-flooring used in this study was manufactured in units of 500×500 mm area and 27 mm thickness. One unit of the MM- flooring was used in experiment 1 (figure 1). The buffer material is a thermoplastic elastomer with a structure based on MM, which is covered with a 1 mm thick vinyl chloride sheet to make a floor material. The following six types of flooring materials and cushions were used for comparison: a carpet tile (polypropylene, 6 mm thickness), vinyl floor (vinyl chloride, 2 mm thickness), *Tatami*, which is a traditional Japanese floor material (rush, 55 mm thickness), rug (polyester, 18 mm thick- ness), joint mat (polyethylene foamed material, 20 mm thick- ness) and shock- absorbing mat (polyethylene and polyurethane foam, 40 mm thickness).

Drop-weightimpacttest

A drop- weight impact testing system to evaluate femur frac- tures developed by Nagoya University was used for the shock- absorbing test.[14] In this system, weight is dropped vertically and impacted with a physical model simulating the thigh of an older Japanese woman to reproduce a fall (figure 2). This test has been used in previous impact evaluation tests since it can evaluate femur fracture risks with changing impact conditions.[15] A steel plate with a mass of 11 kg (area: 300×300 mm, thick- ness: 30 mm) was dropped at a height of 230 mm to render the energy equivalent to the impact on the femur around the great trochanter of a woman with a height of 149.3 cm and weight of 55.3 kg during falling.[16] The height and weight measurements used in the model correspond to the average values of older Japanese women aged 66.9 years old.[17] Each flooring mate- rial was attached to the underside of the steel plate. The femur model was developed based on biomechanics: a simulated bone similar in size to the model of the older woman described above (Sawbones #3414, A Pacific Research Company, USA) was used. Silicon material simulating the shape and the stiffness of the soft tissue of the thigh covers from the proximal to middle area of the femur bone as well as around the greater trochanter. The

load cells were placed at the femoral head to measure the impact force acting on the femur head when the weight collided.

Experiment 2: influence on gait and balance

Participants

Nineteen healthy people aged >65 years (mean age 74.4±6.0, 13 men, 6 women, mean height 162.2±9.6 cm, mean weight 59.7±12.7 kg) participated in this study. This study was conducted on community- dwelling people aged 65 years or older who were publicly invited to participate, and who had a stable general condition and were able to perform daily- life activities independently. They were able to maintain a stable closed- eye standing position on a normal floor.

Floor conditions

The MM-flooring used the same specifications as that in the drop- weight impact test. For the gait performance test, the measurement environment was constructed by arranging 60

units of MM- flooring in a 3×5 m area without gaps, which were covered a 1 mm thick vinyl chloride sheet. For the gait perfor- mance test, the comparison objects were the normal rigid floor surface. For the balance test, a rigid floor and a shock-absorbing mat with an area of 500×500 mm and a thickness of 40 mm (the buffer material parts were polyethylene and polyurethane foam, respectively) were prepared and compared with 1 unit of MM- flooring.

Evaluation of the gait performance

The timed up and go (TUG)[18] and two- step tests[19 20] were adopted as gait performance tests. Two floor conditions, the MM- flooring and rigid floor, were used for evaluating the gait performance.

The TUG is a standard clinical assessment tool, which assesses the balance during a range of activities of daily living (eg, transfers, locomotion and turning).[18] The test involves the participant standing up from a chair, walking forward 3 m at a self-selected speed, turning around, walking back to the chair and reseating themselves. The time from the moment of rising to that of return to the seated posture was measured with a stopwatch. Partic- ipants were measured for each of the clockwise and counter- clockwise turns, and the fastest time was taken as the measured value.

The two-step test was developed as a screening tool for walking ability.[19 20] The participant starts from the standing posture and moves two steps forward with maximum stride with caution to prevent losing balance. If the participant succeeds in holding the final standing position for longer than 3 s without any additional steps, the trial was judged as completed. The distance is then standardised by dividing the participant's height for calculating the two- step test value. The test was performed two times, and the best result was used for the analyses.

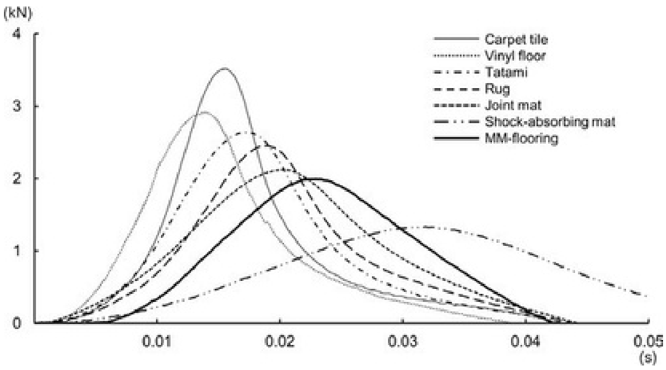

Figure 3 Result of the drop weight impact test. The results of the drop- weight impact tests on seven types of flooring materials, including mechanical metamaterial (MM) floors, are shown. The horizontal axis indicates the time from the moment the weight hits the greater trochanter of the femur model, and the vertical axis indicates the magnitude of the impact on the femur.

Evaluation of balance

The sway during the quiet balance test with force plates[21] and the functional reach test (FRT)[22] were adopted as balance tests. Three floor conditions were used for balance evaluation: MM- flooring, shock- absorbing mat and rigid floor.

The evaluation of sway during quiet stance is a common balance assessment tool owing to its ease in measurement and significant association with fall risk.[21] A portable force platform (AccuGait, Advanced Mechanical Technology, Watertown, Massachusetts) with a custom-written computer program (LabVIEW V.2019 software, National Instruments, Austin, Texas) was used. The platform was equipped with strain gauges that facilitated monitoring of the changes in ground reaction forces. Based on the data collected by the platform, estimating the position and deflection of the centre of pressure (COP) is possible. The external dimensions of this platform were 500×500 mm, and raw data were collected at a frequency of 100 Hz; low- pass filtering with a cut- off frequency of 10 Hz was performed to eliminate noise from the obtained COP displacement signal. Participants were instructed to stand quietly with their legs closed on each floor set up on the force platform. During the quiet stance task, the movement of the COP under the participant's feet with their eyes open and closed was assessed for 10 s each. The rect- angular area was calculated by multiplying the maximum trajectory length of the left–right with anterior–posterior COP displacements for 10 s.

The FRT assesses the functional balance and limit of stability (in centimetres) during standing, which is reliable and valid in older adults.[22 23] The participant was instructed to stand on each floor and close to a wall without touching the wall and position the arm that is close to the wall at a 90° angle of shoulder flexion with the fingers extended. The assessor marked the tip of the middle finger on the wall as the starting position. The participant was instructed: 'Reach forward as far as you can without taking a step'. The location of the middle fingertip at the end of reaching forward was recorded. The difference between the starting and ending positions was measured in centimetres. A larger distance indicates better balance. All the participants performed the procedure two times for each floor condition, and the better score was used.

Data analysis and statistical analysis

For all the tests, the mean and SD of the adopted values for all the participants were calculated and used for comparison. For the gait performance, TUG and two- step tests, a paired t test was used. For the balance and sway during quiet standing tests, as well as the FRT, a one-way analysis of variance (ANOVA) was performed to analyse the effect of the different floor conditions. Tukey's Honestly Significant Differences method for multiple comparisons was used for *post hoc* analysis if a given ANOVA demonstrated a significant main effect. All the statistical analyses were conducted using R V.3.6.1 (2019- 07- 05). Statistical significance was set at p<0.05 for all the tests.

RESULTS

Experiment1 :effectof shock absorbing

Time histories of the load cell force at the femur head in the drop- weight impact tests are shown in figure 3. The maximum force decreased and the time duration increased by attaching the floor materials, which implies that the floor materials absorbed impact energy. The maximum impact force was 3.51, 2.91, 2.64, 2.46, 2.12, 1.33 and 1.98 kN on the carpet tiles, vinyl floor, *tatami*, rug, joint mat, shock- absorbing mat and MM- flooring, respectively.

Experiment2 :influenceonthegait and balance

Evaluation of the gait performance

The TUG results were obtained by analysing the data of 19 participants, with the MM- flooring at 7.5±1.1 s and rigid flooring at 7.4±1.0 s (figure 4). There were no significant differ- ences between the conditions (p=0.548). The two-step test value results were obtained by analysing the data of 19 partic- ipants, with the MM-flooring at 1.3±0.1 and rigid flooring at 1.3±0.1 as shown in figure 4. There were no significant differ- ences between the conditions (p=0.653).

Evaluation of balance

For the rectangular area data of COP displacements, only one participant showed displacements beyond the 95% CI of the data distribution; thus, the data of 18 participants were analysed (figure 5). The values of the rectangular area with opened eyes were 5.0±2.1 cm2, 5.8±2.6 cm2 and 7.1±3.0 cm2 on the MM-flooring, rigid flooring and shock-absorbing mat, respectively. There was a main effect in the three conditions ($F_{2, 34}$ = 3.821, p=0.032). The results of *the post hoc* test showed a significant difference between the MM-flooring and shock-absorbing mat (p=0.026).

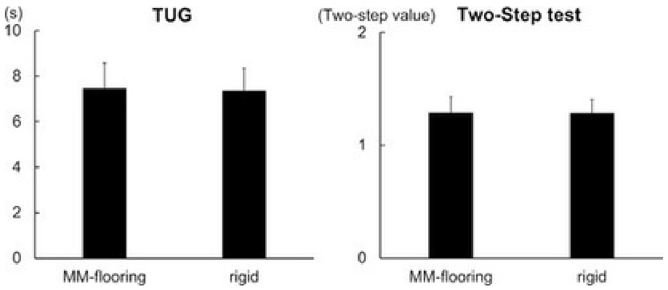

Figure 4 Result of the gait performance test. The mean of the gait performance test results of the 19 participants is shown. Error bars indicate SD. In the TUG test, the shorter time is the better performance. In the graph of the two- step test, the vertical axis indicates the two- step value, which is the distance between two steps divided by the height of each participant; a larger value indicates better performance. MM, mechanical metamaterial;TUG,timed upand go.

The values for the rectangular area with closed eyes were 9.3±4.1 cm2, 10.6±6.8 cm2 and 21.5±10.1 cm2 on the MM- flooring, rigid flooring and shock-absorbing mat, respec- 2ti,v e3l4y .= T here was a main effect in the three conditions (F 27.518, p<0.001). The results of *the post hoc* test showed a significant difference between the MM-flooring and shock-absorbing mat (p<0.001) and between the rigid flooring and shock-absorbing mat (p<0.001).

The FRT results were obtained by analysing the data of 19 participants, with that on the MM-flooring at 31.3±4.9 cm, rigid at 29.6±4.2 cm and the shock-absorbing mat at 30.3±5.4 cm (figure 6). There was no significant difference between the three conditions ($F_{2,\ 36}$ = 2.795, p=0.074).

DISCUSSION

The results of the two experiments (the shock-absorbing test, and the evaluation of gait and balance ability) showed that the newly developed MM- flooring has sufficient shock- absorption to reduce the incidence of fractures attributed to falls without affecting the gait and balance of older adults. It was suggested that the conventional problem of the balance between shock absorption and stability on standing could be solved by the struc- tural property of MM.

In a previous study, some shock- absorbing systems that attenuated impact by approximately 47% compared with a normal floor surface were reported to have a minor effect on the standing balance of older women.6 In this study, compared

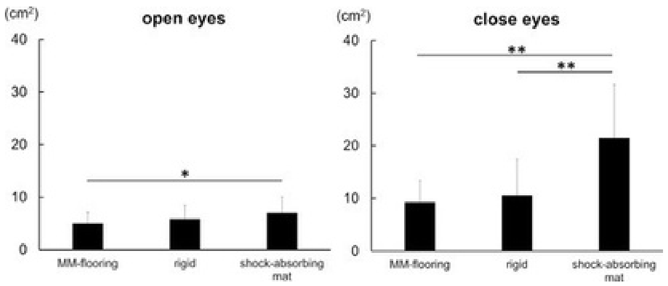

Figure 5 Comparison of the rectangular area of the centre of pressure displacement under each floor condition. The mean of the rectangular area of 18 participants' centre of pressure displacement under each floor condition of is shown. Error bars indicate SD; here, a smaller area is a better performance. *p<0.05, **p<0.001. MM, mechanical metamaterial.

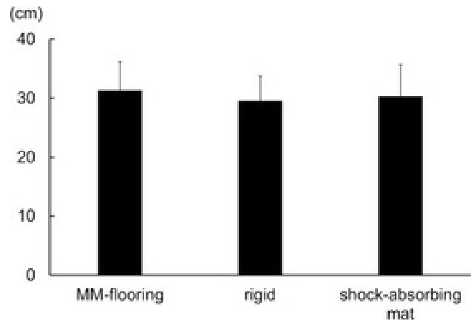

Figure 6 Result of the functional reach test. The mean of the functional reach test results for the 19 participants is shown. Error bars indicate SD; here, the longer distance is the better performance. MM, mechanical metamaterial.

with carpet tiles that have a shock- absorbing performance, the MM-flooring showed a 43.5% reduction in the impact force. Using Kleiven *et al*'s probability curve of hip fracture risk in the older people based on the impact force,24 the probability of hip fracture for carpet tile at the highest impact observed in the present modelling study (3.51 kN) was estimated as 70.5% for women, whereas that for MM- flooring (the highest impact force of 1.98 kN) was estimated as 29.0% for women. Thus, MM- flooring has the potential to substantially reduce the risk of fracture. In addition, there was no effect on the gait or balance when using MM-flooring, suggesting that the flooring mate- rial maintains rigidity during gait and standing and sufficiently reduces the risk of fracture when subjected to instantaneous impacts such as falls.

Economic feasibility is also an important consideration when introducing shock- absorbing flooring materials. According to the Shock- Absorbing Flooring Effectiveness SysTematic (SAFEST) review, some studies found shock-absorbent floors to dominate standard floors, which indicate lower costs and better outcomes. One study estimated that shock-absorbing floors increased both the cost and quality-adjusted life year; however, the quality of these studies is not high.25 The shock-absorbing flooring inter- ventions have the potential to be cost- effective compared with standard flooring, while further research is required to deter- mine whether shock- absorbing flooring is likely to increase the fall rate.26 Since reliable shock-absorbing performance and ease of mass production are important in terms of cost, the MM-flooring has a manufacturing style that is relatively easy to mass produce since the cushioning material is made of elas- tomer and manufactured in units of 500×500 mm area. As of February 2022, MM- flooring has been commercialised by Magic Shields named '*Coroyawa'*, and is now being sold to hospitals and nursing homes in Japan. As the number of installation cases is increasing, further research on the incidence of injuries following installation would confirm the cost- effectiveness of the MM- flooring.

This study has certain limitations. We were not able to compare the same thermoplastic elastomer material with one that had no MM structure as a control in the impact absorp- tion test. Since the thermoplastic elastomer itself possesses a shock- absorbing effect, the effect of the shock- absorbing prop- erty of the MM structure could be more clearly demonstrated by comparing materials with different structures made with thermoplastic elastomer. Furthermore, in the evaluation of gait ability, we could not prepare adequate shock-absorbing flooring to form a walking path for the TUG and two-step tests; thus, we only compared the two groups with a rigid floor. Since a sufficient difference was observed in the balance test, a difference in gait stability is anticipated as well; however, this point needs to be examined closely. In the present study, drop-weight impact testing was performed only in one bone model of an older woman. Simulations with various models of different sex and ages are warranted to enhance the generalisability of the present results.

It was confirmed that MM-flooring has the potential to prevent fractures caused by falls and does not affect the gait or balance of older adults. Further clinical studies would confirm the effectiveness of the MM- flooring in real-world settings.

What is already known on the subject

- ⇒ Shock- absorbing flooring is anticipated to prevent serious injuries after falls.
- ⇒ There is a need to consider the effect of shock- absorbing performance and gait stability when choosing flooring materials.

What this study adds

- ⇒ A flooring material with a mechanical metamaterial structure demonstrated high shock- absorbing properties with no effect on the gait stability of older adults. The possibility of solving
- ⇒ traditional issues with a structural property has been demonstrated.

Correction notice This article has been corrected since it was first published. The open access licence has been updated to CC BY.

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Fall Injury Reduction With Impact Absorbing Flooring – Example 1

JAMDA PALTmed

Low-Impact Flooring: Does It Reduce Fall-Related Injuries?

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Abstract

Objectives

To compare fall rates and injuries from falls on low-impact flooring (LIF) compared with a standard vinyl flooring.

Design

Prospective, observational, nonrandomized controlled study.

Setting

Subacute Older Persons Health ward (N = 20 beds).

Participants

Older inpatients.

Intervention

Three different types of LIF.

Measurements

All falls in the ward were prospectively monitored using incident reporting, noting location and consequences of each fall. Fall rates (per 1000 bed days) and injuries, were compared between bedroom falls on LIF against those occurring on standard vinyl flooring (controls).

Results

Over 31 months, there were 278 bedroom falls (from 178 fallers). The bedroom fall rate (falls per 1000 bed days occupied) did not differ between the LIF and control groups (median 15 [IQR 8–18] versus 17 [IQR 9–23], respectively; $P = .47$). However, fall-related injuries were significantly less frequent when they occurred on LIFs (22% of falls versus 34% of falls on control flooring; $P = .02$). Fractures occurred in 0.7% of falls in the LIF cohort versus 2.3% in the control cohort. Rolling resistance when moving heavier equipment, such as beds or hoists, was an issue for staff on LIF.

Conclusions

LIF significantly reduced fall-related injuries compared with a standard vinyl flooring, whereas they did not alter the overall risk of falling.

Results:

Low Impact Flooring significantly reduced fall-related injuries compared with a standard vinyl flooring, whereas they did not alter the overall risk of falling.

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Fall Injury Reduction With Impact Absorbing Flooring – Example 2

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RESEARCH ARTICLE

A quasi-experimental evaluation of compliant flooring in a residential care setting

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Abstract

Background

Fall injuries affect the lives of older people to a substantial degree. This quasi-experimental observational study investigates the potential fall injury reducing effect of a compliant flooring in a residential care setting.

Methods

The allocation of the compliant flooring was non-random. Data on fall-events and individual characteristics were collected in a residential care unit during a period of 68 months. The primary outcome was the fall injury rate per fall, and a logistic regression analysis was used to test for the effect of complaint flooring. Falls per 1000 bed days was the secondary outcome, used to measure the difference in fall risk on compliant flooring versus regular flooring.

Results

The event dataset is an unbalanced panel with repeated observations on 114 individuals, with 70% women. The mean age was 84.9 years of age, the average Body Mass Index (BMI) was 24.7, and there was a mean of 6.57 (SD: 15.28) falls per individual. The unadjusted effect estimate showed a non-significant relative risk injury reduction of 29% per fall (RR 0.71 [95% CI: 0.46–1.09]) compared to regular flooring. Re-estimating, excluding identified outliers, showed an injury risk reduction of 63% (RR 0.37 [95% CI: 0.25–0.54]). Falls per 1000 bed days showed that individuals living in apartments with compliant flooring had a fall rate of 5.3 per 1000 bed days compared to a fall rate of 8.4 per 1000 bed days among individuals living in regular apartments. This corresponds to an incidence rate ratio (IRR) of 0.63 (95% exact Poisson CI: 0.50–0.80).

Results:

Nursing home (Sweden; quasi-experimental): 59% reduction in injuries for falls on impact-absorbing flooring vs regular floors; later analysis over 68 months reported 63% reduction when outliers were excluded.

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Fall Injury Reduction With Impact Absorbing Flooring – Example 3

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Investigating the fall-injury reducing effect of impact absorbing flooring among female nursing home residents: initial results

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Abstract

Background Fall-related injuries affect the lives of elderly to a substantial degree. This quasi-experimental study investigates the fall-injury reducing effect of impact absorbing flooring among female nursing home residents.

Methods The intervention site is a nursing home in Sweden where impact absorbing flooring was installed in parts of one of six wards (six out of 10 apartments (excluding bathrooms), the communal dining-room and parts of the corridor). The impact absorbing flooring is a 12 mm thick closed cell flexible polyurethane/polyurea composite tile (500×500 mm) with an exterior surface of polyurethane/polyurea. A generalised linear model (log-binomial) was used to calculate the RR of injury from falls on impact absorbing flooring compared to falls on regular flooring, adjusted for age, body mass index, visual and cognitive impairments.

Results During the study period (1 October 2011 to 31 March 2014), 254 falls occurred on regular flooring and 77 falls on impact absorbing flooring. The injury/fall rate was 30.3% for falls on regular flooring and 16.9% for falls on impact absorbing flooring. Adjusted for covariates, the impact absorbing flooring significantly reduced the RR of injury in the event of a fall by 59% (RR 0.41 (95% CI 0.20 to 0.80)).

Conclusions This is, to our knowledge, the first study evaluating the injury-reducing effect of impact absorbing flooring in a nursing home showing statistically significant effect. The results from this study are promising, indicating the considerable potential of impact absorbing flooring as a fall-related injury intervention among frail elderly.

Results:

Hospital (subacute ward, NZ; 31-month prospective cohort): “Low-impact flooring (LIF)” reduced injurious falls by 35% vs standard vinyl; fracture proportion also lower (0.7% vs 2.3%). No increase in fall rates; staff noted higher push–pull forces for heavy equipment.

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Fall Injury Reduction With Impact Absorbing Flooring – Example 4

The influence of headform orientation and flooring systems on impact dynamics during simulated fall-related head impacts

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ABSTRACT

Novel compliant flooring systems are a promising approach for reducing fall-related injuries in seniors, as they may provide up to 50% attenuation in peak force during simulated hip impacts while eliciting only minimal influences on balance. This study aimed to determine the protective capacity of novel compliant floors during simulated 'high severity' head impacts compared to common flooring systems.

A headform was impacted onto a common Commercial-Carpet at 1.5, 2.5, and 3.5 m/s in front, back, and side orientations using a mechanical drop tower. Peak impact force applied to the headform (F_{max}), peak linear acceleration of the headform (g_{max}) and Head Injury Criterion (*HIC*) were determined. For the 3.5 m/s trials, backwards-oriented impacts were associated with the highest F_{max} and *HIC* values ($p < 0.001$); accordingly, this head orientation was used to complete additional trials on three common floors (Resilient Rubber, Residential-Loop Carpet, Berber Carpet) and six novel compliant floors at each impact velocity. ANOVAs indicated that flooring type was associated with all parameters at each impact velocity ($p < 0.001$). Compared to impacts on the Commercial Carpet, Dunnett's post hoc indicated all variables were smaller (25–80%) for the novel compliant floors ($p < 0.001$), but larger for Resilient Rubber (31–159%, $p < 0.01$).

This study demonstrates that during 'high severity' simulated impacts, novel compliant floors can substantially reduce the forces and accelerations applied to a headform compared to common floors including carpet and resilient rubber. In combination with reports of minimal balance impairments, these findings support the promise of novel compliant floors as a biomechanically effective strategy for reducing fall-related injuries including traumatic brain injuries and skull fractures.

Results:

Hospital (subacute ward, NZ; 31-month prospective cohort): "Low-impact flooring (LIF)" reduced injurious falls by 35% vs standard vinyl; fracture proportion also lower (0.7% vs 2.3%). No increase in fall rates; staff noted higher push–pull forces for heavy equipment.

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